Discussion of P5 Letter

A. Seiden

HEPAP Meeting

Sept. 23, 2004

In May 2004 P5 was asked to evaluate the latest BTeV plan for detector completion. We were asked to clarify the comments about the BTeV schedule in the P5 report of September 2003 and the impact of the schedule on physics competitiveness.

The letter to P5 from Robin Staffin and Joe Dehmer was as follows:

Dear Professor Seiden:

On September 29, 2003, the High Energy Physics Advisory Panel (HEPAP) endorsed the Particle Physics Project Prioritization Panel (P5) Report recommending that BTeV be undertaken as quickly as feasible so that it could be completed before 2009. Based on the Report, the Department of Energy granted Critical Decision 0, Statement of Mission Need, to BTeV in February 2004. The Office of Science then conducted a technical, cost and schedule review chaired by Daniel Lehman in April 2004. The conclusion of that review was that the technical scope was adequate to meet the science requirements and that the cost estimate was fairly complete and reliable. However, the presented schedule, "Detector Complete and Ready for Commissioning with Beam by October 2009," was judged to be not achievable with the proposed funding and resource profile.

Fermilab and the BTeV project are preparing a new schedule that may complete the detector in stages. The project will prepare a comparison of the physics reach of LHC-B and BTeV under the new proposed scenario. Please evaluate the physics impact of such a schedule vis a vis LHC-B and provide an evaluation and recommendation. It is our understanding that the Fermilab Physics Advisory Committee (PAC) also plans to do a similar evaluation and provide its findings to P5 as input.

We appreciate your performing this important function. Since the BTeV construction schedule is a critical element for its success, we would like to have your response on this matter as soon as possible and preferably by July 16, 2004.

Rationale for Recommendation of One Year Ago:

Heavy flavor decays are sensitive to new weak-scale physics, which can contribute through loop and box diagrams. As such, these decays provide physics probes that are supportive of the LHC physics program, which directly looks for new particles at this scale. With the International Linear Collider having an earliest start date of 2015, heavy flavor decays may be the main supporting program of LHC physics through the first half of the next decade.

Where are we to date:

Sum of BaBar + Belle provide about 500 fb^{-1} of data.

From summary talk of Owen Long for the DPF 2004 meeting:

$\sin 2\beta = 0.726 \pm 0.037$ Tree diagrams

$\sin 2\beta = 0.42 \pm 0.08$ $b \rightarrow s$ Penguin

$\sigma_\beta = 1.6°$ Tree diagrams

$\sigma_\alpha = 11°$

$\sigma_\gamma = 19°$

Dear Dr. Staffin and Dr. Dehmer:

On September 29, 2003 the High Energy Physics Advisory Panel (HEPAP) endorsed the Particle Physics Project Prioritization Panel (P5) Report recommending that BTeV move forward to a construction start, subject to overall budget constraints within the program, and with a goal that the construction be completed by the end of FY 2009. The special optics for the interaction region, recommended by P5, has since been adopted as part of the project. The recommendation on schedule was primarily to keep BTeV competitive with LHCb, now under construction at CERN, on topics where they compete directly, although for a number of topics BTeV will be clearly superior.

This past year, the BTeV project has started along the path required for the funding agencies to make a final decision on whether to begin construction. The recent Critical Decision 1 review, chaired by Daniel Lehman, examined the potential cost, technical status, and schedule for BTeV construction. Although the cost and technical status were deemed to be very credible for this stage of a project, a scheduled completion date by FY 2009 was seen as too aggressive given the likely timeline for funding. To ameliorate the schedule concerns, BTeV has devised a plan whereby the detector completion is staged, allowing an extra year for the funding profile.

The Lehman committee examined this new schedule and found it to be credible, with sufficient float for the various construction activities. The choices for staging were made such that the first stage detector in 2009 would be fully competitive with LHCb in physics areas of common overlap, as was felt to be desirable by P5, with the complete detector in 2010 allowing BTeV to fully exploit the physics areas in which it has unique capabilities. Your recent letter to P5 asks us to evaluate this physics plan, and in particular whether it is consistent with the expectations on which we based our P5 report.

P5 convened a meeting on July 21 and 22, 2004 to evaluate the physics implications of the BTeV staging plan. This letter summarizes our conclusions from this meeting. The meeting was primarily focused on a general discussion of B physics. This included a look at the impact of new results from the past year, the expected evolution of results from the B factories by 2009, as well as talks from the BTeV spokespersons and the spokesman for LHCb. We also heard from the chair of the Fermilab PAC, who described the PAC's independent assessment of the BTeV plan, and Fermilab Director Witherell, who presented the Fermilab program for the next few years and how the construction of BTeV would fit into this program. We note that prior to our meeting, the Fermilab PAC provided an independent strong unanimous endorsement of the BTeV staging plan.

BTeV will potentially be the flagship experiment in the U.S. in the quark-flavor physics area after LHC startup. In evaluating BTeV, our primary criterion remains that it be the world's best experiment to look at the imprint of new physics found at the LHC in the B^0 and B_s systems, providing a tool to decipher the character of that new physics. BTeV would provide as well a broad and deep program of quark-flavor physics, with access to the meson and baryon states of both the bottom and charm quark systems.

We examined the potential physics output of BTeV approximately ten years from now, particularly in the area of those weak B decays that are unambiguous tests of the underlying weak-scale physics. We also examined potential contributions from running experiments, primarily the two B-factories, and the expectations for LHCb. The B-factory numbers were based on extrapolating results known today to a combined luminosity for both B factories of 3 ab^{-1}, the integrated luminosity that could be expected by the end of 2009. We assumed that the results from the two B-factories could be averaged. The results for BTeV and LHCb are based on their Monte Carlo calculations and integrated luminosities of 9 fb^{-1} and 6 fb^{-1}, respectively.

The results of the above comparisons can be roughly summarized as follows. BTeV will provide an improvement of typically a factor of two in the errors relative to both the B-factories and LHCb on a broad set of measurements of the unitarity triangle angles in the Standard Model for the B^0 system, if the B-factories accumulate no more than 3 ab^{-1} of data. For the B_s, which is not produced at the B-factories, BTeV's errors on the unitarity triangle angles are smaller than those of LHCb by roughly a factor of three.

BTeV would provide a factor of 12 more B decays written to tape than a 3 ab^{-1} B-factory data sample and a factor of 6 more than LHCb. The tagging efficiency is typically expected to be a factor of three lower for BTeV compared to the B-factories and reconstruction efficiencies for the different experiments are channel dependent. For decays involving leptons, the BTeV and LHCb data sets would be comparable, given the specific lepton trigger of LHCb. These general data sets will be particularly useful when looking for forbidden or suppressed decays not requiring tagging or at specific decay channels found to be of interest after the LHC turn-on.

Given our analysis, we find that our conclusions of last year are unchanged in the staging scenario proposed by BTeV and we reaffirm these conclusions. The method of staging chosen by BTeV is an appropriate choice to maximize their physics opportunities.

We want, however, to make several additional comments, which follow from our report of last year. We feel the staging scenario stretches the BTeV schedule as far as we can support. If various constraints, budget or technical, would result in a completion date beyond the end of FY 2010, we would not support a start of the project. There are two reasons for this conclusion. The first is that the physics competitiveness of BTeV would be compromised if it begins too many years after LHC startup. In particular, a start after LHC is fully commissioned and running smoothly for several years will allow LHCb to extensively examine the B_s system, which is the unique physics area of the experiments at the hadron colliders.

Secondly, the U.S. has an exciting agenda of other projects outlined in our Roadmap, with new projects being invented as we learn more about the universe. These projects compete for funds and require timely support. The stretching out of projects, including the additional cost for running accelerators, delay the onset of these other exciting projects. Finally, the BTeV capital and operating costs presented to us are somewhat higher than we had expected, based on our studies last year. This is the case even after accounting for the new IR optics, which we continue to support as essential for providing enough luminosity for BTeV. Given the needs for support of future projects, we would not like to see additional cost increases for BTeV in the future.